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MEMORANDUM

To: Sheldon Reddekopp (BC ENV) and Lauren Sullivan (MT DEQ)

From: David DeForest

Subject: Comments on Levels of Protection and a Site-specific Selenium Objective for Koocanusa Reservoir

Date: August 2, 2019

Synopsis

The objective of the Selenium Technical Subcommittee (SeTSC) is to provide recommendations for a site-specific selenium (Se) objective or criterion for Koocanusa Reservoir. Draft “levels of protection” provided to the SeTSC for review and comment are based on provincial British Columbia Ministry of Environment and Climate Change Strategy (BC ENV) guidelines and national U.S. Environmental Protection Agency (USEPA) criteria (Reddekopp and Sullivan 2019). In my opinion, levels of protection should also reflect regulatory guidance for development of site-specific objectives and criteria. This guidance supports the use of effects-based data representative of species that occur at a site (i.e., effects data for species at a site or for closely related surrogate species).

1 Introduction

This memorandum provides additional comments¹ on the draft levels of protection for developing a site-specific Se objective/criterion for Koocanusa Reservoir, along with recommendations for additional levels of protection options consistent with regulatory guidance for developing site-specific objectives and criteria. Currently, the draft levels of protection are linked to provincial (BC ENV) Se guidelines and national (USEPA) Se criteria. It is understandable that these existing guidelines and criteria would be a starting

¹ Comments have previously been provided on March 26, 2019 (“Comments on *Proposed Workplan for Developing a Site-Specific Selenium Water-Column Criterion for Lake Koocanusa*”) and June 5, 2019 (“Use of Fish Species-specific Selenium Toxicity Thresholds in Bioaccumulation Models”).

point for incorporation of effects-based thresholds. However, because the purpose of the SeTSC is to recommend site-specific Se objective/criterion options for Koocanusa Reservoir, consideration should be given to levels of protection that incorporate all relevant site-specific information.

In my previous comments to the SeTSC,¹ I noted that whether a given water Se concentration results in an adverse effect to a given fish species depends on the combination of both the Se bioaccumulation potential and the Se sensitivity for that species. For instance, if Species A has an egg Se threshold that is one-half of the threshold for Species B, but the Se bioaccumulation potential of Species B is two-times that of Species A, both species would have the same back-calculated water Se threshold. Currently, species-specific Se bioaccumulation potential is being evaluated in Se bioaccumulation models used to derive potential site-specific Se objectives/criteria, but species-specific Se sensitivity is not. This is inconsistent with typical approaches and sound science for deriving site-specific objectives and criteria.

2 Site-specific Objectives/Criteria Approaches

In the US, there are two approaches for developing site-specific water quality criteria that explicitly consider the sensitivity of local species:

- **Recalculation Procedure:** This procedure accounts for differences in the sensitivity of resident species to a chemical. For example, the *Revised Deletion Process for the Site-Specific Recalculation Procedure for Aquatic Life Criteria* (USEPA 2013a) provides guidance on revising the taxonomic composition of the toxicity data set used for the sensitivity distribution upon which a site-specific criterion is based, such that it better reflects the assemblage of organisms that occurs at a site.

The USEPA provides an example of the recalculation procedure in its ambient water quality criteria document for ammonia (USEPA 2013b), in which it is noted that “The recalculation procedure for site-specific criteria derivation is intended to allow site-specific criteria that differ from national criteria recommendations (i.e., concentrations that are higher or lower than national recommendations) where there are demonstrated differences in sensitivity between the aquatic species that occur at the site and those that were used to derive the national criteria recommendations.” BCMOE (2016) similarly notes that site-specific WQOs are appropriate where species used to derive the water quality guideline do not exist and analogous recalculation procedure guidance is provided BCMOE (2013).

- **Resident Species Procedure:** This is a procedure that accounts for both differences in sensitivity of resident species to a chemical and differences in bioavailability due to site characteristics.

Thus, site-specific water quality criteria guidance provides approaches for considering both site-specific bioavailability and the sensitivity of local species. The former is already being considered in developing a site-specific Se bioaccumulation model, but the latter is thus far not being considered. There is a technical basis for linking species-specific

bioaccumulation models with corresponding species-specific effects thresholds, as available, due to the interrelationship between Se bioaccumulation and sensitivity in determining the susceptibility of fish species to Se toxicity. Further, there is regulatory support for considering the sensitivity of local species when developing site-specific criteria.

3 Recommended Hierarchy for Identifying Fish Tissue-based Selenium Thresholds for Koocanusa Reservoir Fish Species

Selenium toxicity data are available for many fish species in Koocanusa Reservoir, or for closely related species. As noted in Section 5 (Site-specific Criteria) of USEPA (2016), “All four elements of the freshwater selenium criterion may be modified to reflect site-specific conditions where the scientific evidence indicates that different values will be protective of aquatic life and provide for the attainment of designated uses” and “Since the fish egg-ovary criterion element is based on toxicity data, a state may modify that element by applying the Recalculation Procedure to edit the species toxicity database to reflect taxonomic relatedness to the site assemblage, while including tested surrogates for untested resident species.” Consistent with this guidance, one recommendation is to consider the following hierarchy in selecting Se thresholds for fish species in Koocanusa Reservoir:

1. Use species-specific thresholds;
2. Use thresholds for closely related species (e.g., same genus); and
3. In the absence of a species-specific or closely related species threshold, use USEPA criteria (USEPA 2016) or BC ENV guidelines (BCMOE 2014).

To illustrate this proposed hierarchical approach, I updated the USEPA’s Se toxicity database (USEPA 2016) with additional studies (Table 1). Then, potential fish egg selenium thresholds were identified for the 13 fish species identified by SeTSC members as being of primary interest (Table 2). Each of these species could potentially be considered in developing a site-specific selenium objective/criterion for the reservoir. These fish species thresholds could be paired with their respective Se bioaccumulation models for Koocanusa Reservoir to develop a range of back-calculated water Se concentrations, from which a protective site-specific water Se criterion could be identified.

4 Example of Potential Modification to Levels of Protection Definition

The following is an example of how the level of protection definition could be revised based on the recommendation provided herein:

The model-derived water-column criterion will provide a level of protection ensuring that the population mean for any species in the reservoir will not exceed its species-defined threshold, which is defined based on the following hierarchy: (a) species-specific EC10; (b) EC10 from intra-genus surrogate; or (c) the USEPA criterion of 15.1 mg/kg dw or BC ENV guideline of 11 mg/kg dw.

5 Summary and Conclusions

- The current plan for developing a site-specific Se criterion for Koocanusa Reservoir relies upon a site- and species-specific Se bioaccumulation model, but levels of protection based on toxicity thresholds that are not related to local species.
- Site-specific objective and criteria guidance in BC and the US provide procedures that account for the sensitivities of local species and their closely related surrogates.
- The concept of using fish species-defined Se thresholds, which are defined upon a hierarchy—(1) species-specific; (2) intra-genus surrogate; and (3) USEPA criterion—could be readily incorporated into the levels of protection and would be consistent with site-specific objective and criteria guidance.

6 References

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Table 1. Egg/ovary selenium toxicity thresholds for North American freshwater fish.

Species	Statistical Endpoint	Species Mean Egg or Ovary Se (mg/kg-dw)	Genus Mean Egg or Ovary Se (mg/kg-dw)	Original Study Reference	Source of Toxicity Value Selected ¹
<i>Salvelinus malma</i> (Dolly Varden)	EC10	56.2	56.2 ^a	McDonald et al. 2010	USEPA 2016
<i>Salvelinus fontinalis</i> (brook trout)	NOEC	>20		Holm 2002; Holm et al. 2003, 2005	USEPA 2016
<i>Xyrauchen texanus</i> (razorback sucker)	MATC	41.9	41.9	Hamilton et al. 2005a,b	DeForest et al. 2012
<i>Esox lucius</i> (northern pike)	EC24	34	34	Muscatello et al. 2006	USEPA 2016
<i>Thymallus arcticus</i> (Arctic grayling)	NOEC	>33.9	>33.9	Windward et al. 2018	Windward et al. 2018
<i>Prosopium williamsoni</i> (mountain whitefish)	NOEC	>33.2	>33.2	Nautilus 2013	Nautilus 2013
<i>Cyprinodon macularius</i> (desert pupfish)	EC10	27	27	Besser et al. 2012	USEPA 2016
<i>Micropterus salmoides</i> (largemouth bass)	EC10	26.3	26.3	Carolina Light and Power 1997	USEPA 2016
<i>Pimephales promelas</i> (fathead minnow)	LOEC	<25.6	<25.6	Schultz and Hermanutz 1990	USEPA 2016
<i>Oncorhynchus clarkii lewisi</i> (westslope cutthroat trout)	EC10	26.2	25.2 ^b	Rudolph et al. 2008; Nautilus 2011	USEPA 2016
<i>Oncorhynchus clarkii bouvieri</i> (Yellowstone cutthroat trout)	MATC	25		Formation Environmental 2011a	DeForest et al. 2012
<i>Oncorhynchus mykiss</i> (rainbow trout)	EC10	24.5		Holm 2002; Holm et al. 2003, 2005	USEPA 2016
<i>Cottus cognatus</i> (slimy sculpin)	NOEC	>22	>22	Lo et al. 2014	Lo et al. 2014
<i>Salmo trutta</i> (brown trout)	EC10	21	21	Formation Environmental 2011b	USEPA 2016
<i>Lepomis macrochirus</i> (bluegill)	EC10	20.6	20.6	Doroshov et al. 1992; Coyle et al. 1993; Hermanutz et al. 1992, 1996	USEPA 2016
<i>Acipenser transmontanus</i> (white sturgeon)	EC10	15.6	15.6	Linville 2006	USEPA 2016

¹ EC10 values (or alternative statistical endpoints) were not always provided in the original study source, so source of value is provided.

^a The genus mean value for *Salvelinus* was set equal to the EC10 for Dolly Varden, as no effects were observed in brook trout at the highest concentration tested.

^b Although the statistical endpoint for Yellowstone cutthroat trout was an MATC, it was geometrically averaged with the EC10 values for westslope cutthroat trout and rainbow trout because values for all three species were similar.

EC10 = 10% effect concentration

EC13 = 13% effect concentration

EC24 = 24% effect concentration

NOEC = no-observed-effect concentration

LOEC = lowest-observed-effect concentration

MATC = maximum acceptable toxicant concentration (geometric mean of NOEC and LOEC)

Table 2. Potential egg selenium thresholds for fish in Koocanusa Reservoir

Family	Genus	Species	Sensitivity to Selenium	Egg Se Threshold (mg/kg dw)
Salmonidae	<i>Salvelinus</i>	Bull trout (<i>Salvelinus confluentus</i>)	Sensitivity of bull trout to Se has not been tested. However, sensitivity of Dolly Varden (<i>Salvelinus malma</i>), a closely related species, was evaluated by McDonald et al. (2010). The egg Se EC10 was 56.2 mg/kg dw (consistent with EC10 derived in USEPA [2016]).	56.2 (intra-genus surrogate)
	<i>Oncorhynchus</i>	Kokanee (<i>Oncorhynchus nerka</i>)	Sensitivity of kokanee salmon to Se has not been tested. Se toxicity data for other species in the genus <i>Oncorhynchus</i> are available (rainbow trout, westslope cutthroat trout, and Yellowstone cutthroat trout). Rainbow trout and westslope cutthroat trout have egg Se EC10s ranging from about 22-26 mg/kg dw (see below), while an egg Se MATC of 25 mg/kg dw for Yellowstone cutthroat trout is available (Formation Environmental 2012a). The most sensitive species in the genus <i>Oncorhynchus</i> (rainbow trout) was used to estimate an egg Se threshold for Kokanee.	24.5 (intra-genus surrogate)
		Rainbow trout (<i>Oncorhynchus mykiss</i>)	Sensitivity of rainbow trout to Se was evaluated based on field-exposed fish in the Upper McLeod River and Upper Gregg River watersheds in Alberta (Holm 2002; Holm et al. 2003, 2005). An egg Se EC10 of 24.5 mg/kg dw was derived by USEPA (2016). The EC10 of 24.5 mg/kg dw was used to define the sensitivity of rainbow trout.	24.5 (species-specific)
		Westslope cutthroat trout (<i>Oncorhynchus clarki lewisi</i>)	Sensitivity of westslope cutthroat trout to Se was evaluated based on field-exposed fish in the Elk Valley watershed (Kennedy et al. 2000; Rudolph et al. 2008; Nautilus Environmental and Interior Reforestation Co. Ltd. 2011). A geometric mean egg Se EC10 of 26.2 mg/kg dw was derived by USEPA (2016) based on Rudolph et al. 2008 and Nautilus Environmental and Interior Reforestation Co. Ltd. (2011). The latter was used to define the sensitivity of westslope cutthroat trout.	26.2 (species-specific)
	<i>Prosopium</i>	Mountain whitefish (<i>Prosopium williamsoni</i>)	Nautilus Environmental (2013) evaluated the sensitivity of mountain whitefish to Se, based on field-exposed fish in the Elk River watershed, and did not observe adverse effects at the highest egg Se concentration tested (33.2 mg/kg dw). The egg Se toxicity threshold for mountain whitefish was, therefore, defined as >33.2 mg/kg dw.	>33.2 (species-specific)

Comments on Levels of Protection and a Site-specific Selenium Objective

August 2, 2019

Page 9

Family	Genus	Species	Sensitivity to Selenium	Egg Se Threshold (mg/kg dw)
Catostomidae	<i>Catostomus</i>	Largescale sucker (<i>Catostomus macrocheilus</i>)	No Se toxicity data are available for largescale sucker. Without additional information, thresholds of 15.1 and 11 mg/kg dw are considered.	15.1 (USEPA criterion) 11 (BC ENV guideline)
		Longnose sucker (<i>Catostomus catostomus</i>)	No reliable Se toxicity data are available for longnose sucker. Without additional information, thresholds of 15.1 and 11 mg/kg dw are considered.	15.1 (USEPA criterion) 11 (BC ENV guideline)
Cyprinidae	<i>Ptychocheilus</i>	Northern pikeminnow (<i>Ptychocheilus oregonensis</i>)	No Se toxicity data are available for northern pikeminnow, but an effects study is in progress (spring/summer 2019). The only cyprinid with a Se toxicity threshold is fathead minnow (<i>Pimephales promelas</i>), which appears to be comparable in sensitivity to several other fish species (LOEC of 25.6 mg/kg dw). Without additional information and pending results of ongoing studies, thresholds of 15.1 and 11 mg/kg dw are considered.	15.1 (USEPA criterion) 11 (BC ENV guideline) <i>Note: Species-specific effects study in-progress</i>
	<i>Mylocheilus</i>	Peamouth chub (<i>Mylocheilus caurinus</i>)	No Se toxicity data are available for peamouth chub. Without additional information, thresholds of 15.1 and 11 mg/kg dw are considered.	15.1 (USEPA criterion) 11 (BC ENV guideline)
	<i>Richardsonius</i>	Redside shiner (<i>Richardsonius balteatus</i>)	No Se toxicity data are available for redside shiner, but an effects study is in progress (spring/summer 2019). Without additional information and pending results from ongoing studies, thresholds of 15.1 and 11 mg/kg dw are considered.	15.1 (USEPA criterion) 11 (BC ENV guideline) <i>Note: Species-specific effects study in-progress</i>

Comments on Levels of Protection and a Site-specific Selenium Objective

August 2, 2019

Page 10

Family	Genus	Species	Sensitivity to Selenium	Egg Se Threshold (mg/kg dw)
Percidae	<i>Perca</i>	Yellow perch (<i>Perca flavescens</i>)	No Se toxicity data are available for yellow perch. Without additional information, thresholds of 15.1 and 11 mg/kg dw are considered.	15.1 (USEPA criterion) 11 (BC ENV guideline)
Lotidae	<i>Lota</i>	Burbot (<i>Lota lota</i>)	No Se toxicity data are available for burbot. Without additional information of 15.1 and 11 mg/kg dw are considered.	15.1 (USEPA criterion) 11 (BC ENV guideline)